

HIGHEST ORDOVICIAN (HARTFELL SHALES) GRAPTOLITE FAUNAS FROM THE MOFFAT AREA, SOUTH SCOTLAND

By P. TOGHILL

CONTENTS

	Page
I. INTRODUCTION	4
II. LITHOLOGY AND GRAPTOLITE FAUNA OF THE HIGHEST HARTFELL SHALES, MAIN CLIFF, DOBB'S LINN	6
III. DISCUSSION OF THE HIGHEST ORDOVICIAN GRAPTOLITE ZONES	7
IV. THE CARADOC-ASHGILL BOUNDARY IN THE GRAPTOLITIC SEQUENCE	9
V. SYSTEMATIC DESCRIPTIONS	10
Genus <i>Dicellograptus</i> Hopkinson	10
<i>Dicellograptus anceps</i> (Nicholson)	10
<i>Dicellograptus complanatus</i> Lapworth	12
<i>Dicellograptus ornatus</i> Elles & Wood	14
<i>Dicellograptus ornatus minor</i> subsp. nov.	16
<i>Dicellograptus moffatensis</i> (Carruthers)	17
<i>Dicellograptus morrissi</i> Hopkinson	17
<i>Dicellograptus carruthersi</i> sp. nov.	18
<i>Dicellograptus</i> cf. <i>elegans</i> (Carruthers)	19
Genus <i>Pleurograptus</i> Nicholson	20
<i>Pleurograptus linearis</i> (Carruthers)	20
Genus <i>Leptograptus</i> Lapworth	20
<i>Leptograptus capillaris</i> (Carruthers)	20
Genus <i>Glyptograptus</i> Lapworth	21
<i>Glyptograptus nicholsoni</i> sp. nov.	21
Genus <i>Diplograptus</i> M'Coy	21
<i>Diplograptus fastigatus</i> (Davies)	21
Genus <i>Climacograptus</i> Hall	22
<i>Climacograptus hvalross</i> Ross & Berry	22
<i>Climacograptus supernus</i> Elles & Wood	22
<i>Climacograptus latus</i> Elles & Wood	22
<i>Climacograptus styloideus</i> Elles & Wood	22
<i>Climacograptus scalaris miserabilis</i> Elles & Wood	23
Genus <i>Orthograptus</i> Lapworth	23
<i>Orthograptus quadrimucronatus</i> (Hall)	23
<i>Orthograptus truncatus truncatus</i> (Lapworth)	23
<i>Orthograptus truncatus abbreviatus</i> Elles & Wood	24
<i>Orthograptus truncatus pauperatus</i> Elles & Wood	24
<i>Orthograptus truncatus socialis</i> (Lapworth)	24
VI. ACKNOWLEDGMENTS	24
VII. REFERENCES	25

SYNOPSIS

The stratigraphy and graptolite fauna of the highest Ordovician (Hartfell Shales) graptolite zones of *Dicellograptus anceps*, *D. complanatus* and *Pleurograptus linearis*, exposed at Dobb's Linn, 10 miles north-east of Moffat, Scotland, is reviewed for the first time since Lapworth's original (1878) work. These three zones are 4.6 m. (15 ft.), 9.5 m. (31 ft.), and 4.9 m. (16 ft.) thick. The status and distribution of the zones is discussed, and it is suggested that the Ashgill Series is equivalent to only part of the *D. anceps* Zone. A large dicellograptid fauna is described including *D. carruthersi* sp. nov., and *D. ornatus* (= *D. complanatus* var. *ornatus* Elles & Wood) is considered a distinct species with a new subspecies *D. ornatus minor*. Lectotypes from original collections are chosen for *D. anceps*, *D. complanatus* and *D. ornatus*, and the remaining fauna includes *Glyptograptus nicholsoni* sp. nov., the first glyptograptid described from the higher Ordovician of Britain.

I. INTRODUCTION

THE Hartfell Shales of the Moffat area (Lapworth 1876, 1878) incorporate the higher Ordovician graptolite zones of *Climacograptus wilsoni*, *Dicranograptus clingani*, *Pleurograptus linearis*, *Dicellograptus complanatus*, and *D. anceps*. These zones are generally accepted as standard divisions of the British Ordovician, and are accepted as being equivalent to part of the Caradoc Series, and the whole of the Ashgill Series. Exact correlations between shelly and graptolitic facies have always been controversial, particularly the exact placing of the Caradoc-Ashgill boundary in the graptolitic sequence. The controversies are in some measure due to the fact that the stratigraphy of the Hartfell Shales has not been reviewed since Lapworth's original work (1878), and the fauna not since Elles and Woods "Monograph" (1901-1918).

Although originally defined by Lapworth in 1876 the Hartfell Shales were not described in detail by him until 1878. They are the middle division of his condensed graptolitic sequence, the Moffat Series, overlain by the Birkhill Shales (Llandoverly) and underlain by the Glenkiln Shales (lower Caradoc). The division was named after Hartfell Spa (4 miles north of Moffat) where according to Lapworth (1878: 253) the beds were most perfectly exhibited. However because the beds there are highly contorted (Lapworth 1878: 292) Lapworth used the section exposed on the Main Cliff (Pl. 1), Dobb's Linn, 10 miles N.E. of Moffat, as his standard sequence for the Hartfell Shales (Lapworth 1878: 309, 315), except for the *wilsoni* Zone which was measured up at Hartfell Spa.

At Dobb's Linn the Hartfell Shales fall naturally into two lithological divisions, well exposed on the Main Cliff. A lower division of approximately 14 m. of black pyritic mudstones (zones of *Climacograptus wilsoni*, *Dicranograptus clingani*, and *Pleurograptus linearis*), and an upper division of equal thickness of barren grey mudstones with only a few thin graptolitic bands (*complanatus* and *anceps* Zones). These units were defined by Lapworth as the Lower and Upper Hartfell Shales, and the latter were sometimes referred to as the Barren Mudstones Group (Lapworth 1878: 254), although the terms "zone of Barren Mudstone" and "Barren Mudstones" were usually used for the lower part of the Upper Hartfell Shales, later (1880a: 198) defined by him as the *complanatus* Zone.

The Hartfell-Birkhill boundary is in fact the Ordovician-Silurian boundary and the base of the Birkhill Shales (*persculptus* Zone) as exposed on the Main Cliff

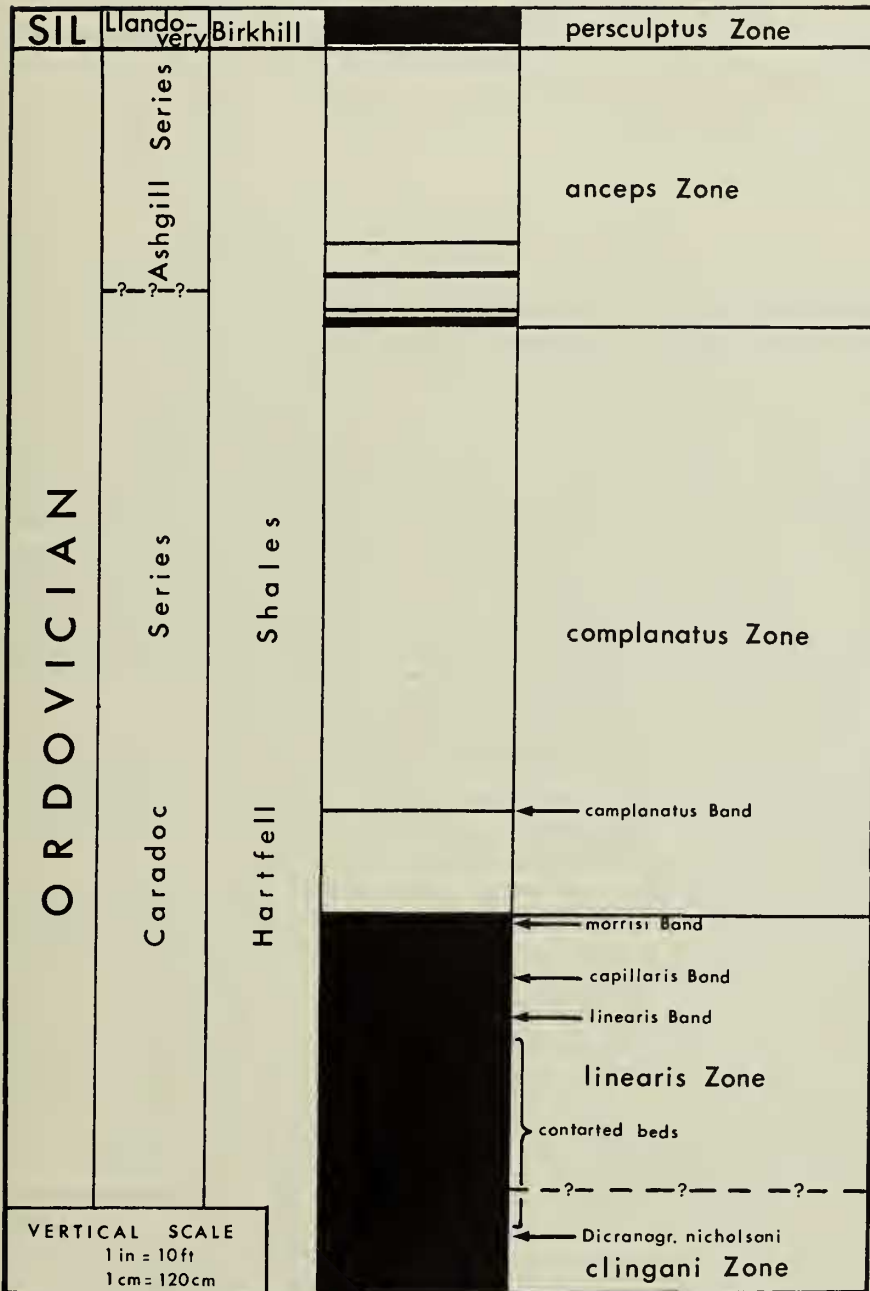


FIG. 1. Vertical section through the highest Ordovician of the Main Cliff, Dobb's Linn, showing the distribution of fossiliferous black mudstones, and (uncoloured) barren grey mudstones.

(Toghill 1968 : 658) has recently been set up as the standard base for the Llandovery Series and hence the Silurian System (Cocks, Toghill and Ziegler 1970 : in press).

This work covers the stratigraphy and graptolite fauna of the three highest Ordovician graptolite zones (*P. linearis*, *D. complanatus* and *D. anceps*) as exposed at the type locality of Dobb's Linn, and measured up on the Main Cliff, Dobb's Linn (Toghill 1968 : 656, Text-fig. 1).

II. LITHOLOGY AND GRAPTOLITE FAUNA OF THE HIGHEST HARTFELL SHALES, MAIN CLIFF, DOBB'S LINN

Zone of *Dicellograptus anceps*. 4.6 m. of beds exposed in the Main Cliff Section (Text-fig. 1) are assigned to this zone. The basal beds of the Birkhill Shales form a conspicuous overhang visible all along the Main Cliff (Pl. 1), and immediately overlie 3.1 m. of barren grey mudstones with thin soft pale coloured claystones (? pyroclastic). These barren mudstones overlie 1.4 m. of similar beds but with four rusty weathering black mudstones which are in descending order 51, 102, 25 and 152 mm. thick (Text-fig. 1). These four bands are highly fossiliferous containing the following common species: *Dicellograptus anceps* (Nicholson), *Climacograptus supernus* Elles and Wood, *C. scalaris miserabilis* Elles and Wood, and *Orthograptus truncatus abbreviatus* Elles and Wood. The following also occur, *Dicellograptus ornatus* Elles and Wood, *D. ornatus minor* subsp. nov., *D. complanatus complexus* Davies, *Climacograptus latus* Elles and Wood, *C. hvalross* Ross and Berry, *Diplograptus fastigatus* (Davies), *Nymphograptus velatus* Elles and Wood, ?*Neurograptus* sp., *Orthograptus truncatus truncatus* (Lapworth), *O. truncatus socialis* (Lapworth), *Glyptograptus nicholsoni* sp. nov. and *Plegmatograptus nebula* Elles & Wood.

Zone of *Dicellograptus complanatus*. The 152 mm. fossiliferous bed at the base of the *anceps* Zone overlies approximately 9.5 m. of grey and greyish green mudstones, massively bedded in the highest 4.6 m. but more shaley in the lower half. This unit is Lapworth's original "zone of Barren Mudstone" and immediately overlies black graptolitic mudstones of the *linearis* Zone.

About 1.5-1.8 m. above the base of this grey mudstone unit occurs a very conspicuous 40 mm. band of fossiliferous black shale, hereafter called the *complanatus* Band, well exposed at the northeast corner of the Main Cliff (Pl. 1), but covered by talus in the central part of the section. The thickness of barren grey mudstones between the band and the *linearis* Zone, given here as 1.5-1.8 m., is difficult to estimate owing to contortion of the beds. The *complanatus* Band is crowded with poorly preserved examples of *Dicellograptus complanatus* Lapworth, *Orthograptus truncatus socialis* (Lapworth), and *Climacograptus scalaris miserabilis* Elles and Wood, with rare examples of *Plegmatograptus nebula* Elles and Wood.

Zone of *Pleurograptus linearis*. The barren grey mudstones at the base of the *complanatus* Zone immediately overlie fossiliferous black pyritic mudstones with thin soft pale coloured (?pyroclastic) claystones. The highest 1.8 m. are fossiliferous throughout, but the zone is characterized by bedding planes crowded with one particular species almost to the exclusion of all others. This is particularly true of the orthograptids, but almost all species seem to have a gregarious habit.

The highest 0.3 m. of the zone contains one bedding plane crowded with *Dicello-*

graptus pumilus Lapworth, and *D. morrissi* Hopkinson, and another crowded with *Orthograptus truncatus pauperatus* Elles and Wood. The following also occur, *O. truncatus socialis*, *O. quadrimucronatus* (Hall), *Plegmatograptus nebula* Elles and Wood, *Dicellograptus* cf. *elegans* (Carruthers), *D.* cf. *elegans rigens* Elles and Wood, *D. moffatensis* (Carruthers), *D. carruthersi* sp. nov.

The underlying 0.6 m. of strata are not very fossiliferous but yield good specimens of *Orthograptus quadrimucronatus* together with *Climacograptus scalaris miserabilis*, *Dicellograptus pumilus*, and *D. carruthersi*.

The next 0.6 m. of strata contain one bedding plane crowded with *Leptograptus capillaris* (Carruthers), a species limited to this one horizon, and numerous other levels are crowded with *Orthograptus truncatus pauperatus*. *Climacograptus styloideus* Elles and Wood is restricted to this horizon which has yielded one example of *Pleurograptus linearis simplex* Elles and Wood, and also the following: *Leptograptus flaccidus* (Hall), *L. flaccidus arcuatus* Elles and Wood, *Dicellograptus moffatensis*, *D. morrissi*, *D. pumilus*, *D. forchammeri* (Geinitz). *Orthograptus truncatus truncatus*, *O. truncatus socialis*, *Climacograptus scalaris miserabilis* and *Plegmatograptus nebula*.

The underlying 0.6 m. of strata contains the only prolific horizon of *Pleurograptus linearis* (Carruthers), 1.5–2.1 m. below the top of the zone. The species occurs associated with *Leptograptus flaccidus*, *Orthograptus quadrimucronatus*, and *Orthograptus truncatus* s.l. (Lapworth).

Below this level on the Main Cliff there is a good deal of strike faulting, and the beds appear unfossiliferous until an horizon 3.4 m. below the *P. linearis* horizon yields *Dicranograptus nicholsoni* and *D. ramosus* indicating a level in the *D. clingani* Zone. On this evidence as much as 4.9 m. could be assigned to the *linearis* Zone.

III. DISCUSSION OF THE HIGHEST ORDOVICIAN GRAPTOLITE ZONES

The *Dicellograptus anceps* Zone has been accepted as the highest Ordovician graptolite zone in Britain, but apart from Scandinavia (Törnquist 1890) the zone fossil has not been recorded with any certainty from any other part of the world. The records from Australia (Thomas 1960) have not yet been figured. However, other elements of the fauna of the *anceps* Zone present in Scotland occur elsewhere in the world, in particular *Dicellograptus ornatus* which is widely recorded from N. America (Ruedemann 1947, Berry 1960, Churkin 1963), and Australia (Hall 1906). *Climacograptus hvalross* recorded here was originally found in the highest Ordovician of Nevada (Ross and Berry 1963). *Orthograptus truncatus abbreviatus* is widely recorded from North America and Australia, so there is little doubt that the *anceps* Zone has a world-wide distribution even if the index species has not. Because of the lack of this zone fossil in other areas the highest Ordovician is referred to as the zone of *Dicellograptus complanatus* or *D. complanatus ornatus* in Scandinavia, Australia, and North America (Tullberg 1882, Moberg 1911, Thomas 1960, Ross and Berry 1963).

In Britain *D. anceps* is abundant only in the Moffat area. However, Mrs. Gray recorded it (Peach & Horne 1899 : 525) from the Drummuck Group of the Girvan area, but strangely this is not cited by Elles and Wood (1904). Dr. Ingham has very kindly sent me graptolites which he has collected from the highest Ordovician

of the Girvan area, including a specimen of *D. anceps* from the Shalloch Formation (=Barren Flagstones) below the Drummuck Group (Text-fig. 4a) at Woodland Point. These beds immediately overlie the Upper Whitehouse Formation which contains *D. complanatus* in abundance. The significance of this in placing the Caradoc-Ashgill boundary in the graptolite sequence will be discussed below.

Contrary to popular belief, *D. anceps* was not recorded by Swanston and Lapworth (1877) from Northern Ireland, but was later found at Coal Pit Bay by Clark (1902), and at Pomeroy by Fearnside, Elles and Smith (1907). Dr. Rushton of the Institute of Geological Sciences has kindly allowed me to see good specimens of *D. anceps* collected by the Geological Survey during a re-survey of the Northern Ireland One-Inch Sheet 36 (Belfast). Although recorded from Wales (Jones 1909, Pugh 1923), the preservation of these specimens is extremely poor.

The status of the *Dicellograptus complanatus* Zone has always been in doubt, not so much because of the validity of the species, which is in fact a well defined form with a wide distribution, but because the zone fossil is restricted to a 40 mm. band within a barren mudstone sequence at the type locality.

The *complanatus* Zone is defined here as all the barren mudstones occurring between the base of the lowest fossiliferous band of the *anceps* Zone, and the top of the black mudstones of the *linearis* Zone. The fauna is restricted to the *complanatus* Band 1.5–1.8 m. above the base of the zone. Lapworth (1878: 316) stated that the fossiliferous band "near to the base of the zone of Barren Mudstone" contained *Dicellograptus forchammeri*, *Climacograptus scalaris?* and *Diplograptus truncatus*. He later (1880: 160–161) described *D. complanatus* sp. nov. from this band, this new species presumably being what he had earlier (1878: 316) referred to as *D. forchammeri*, and then (1880a: 198) he referred to the barren mudstones as the *D. complanatus* Zone. Lapworth stated (1880: 161), in his original description, that *D. complanatus* occurred in the corresponding zone in the Hartfell Shales of County Down, and indeed Swanston (1877: 111) recorded *D. forchammeri* from a black shale fragment in grey mudstones at Coal Pit Bay, but Dr. Rushton informs me that the Geological Survey have not found this locality during a re-survey of Coal Pit Bay. The *complanatus* Zone was accepted by Elles and Wood (1914) and has been accepted ever since, but with reservations.

Elles (1925: 343) considered the fauna of the *complanatus* Zone to be "largely dwarfed" and the horizon to be "purely pathological", and stated that the fauna "seems to be almost invariably associated with a Barren Mudstone type of sediment. When the sedimentation is more normal a different fauna is found in which *Climacograptus styloideus* is the commonest and most characteristic graptolite". She concluded, "Whether this is a sub-zone of the *P. linearis* Zone or represents a still higher horizon cannot yet be stated definitely."

The more normal sedimentation to which Elles was referring was in the Berwyn Hills, where King (1923: 492) obtained a fauna from the Pen-y-garnedd shales which Elles identified as including *Orthograptus quadrimucronatus*, *O. calcaratus basilicus*, *O. truncatus pauperatus*, and *Climacograptus styloideus*, and she there stated that this represented the highest *linearis* Zone! It is not at all clear why, in 1925, she thought this fauna to be equivalent to the *complanatus* Band as, except for

Orthograptus calcaratus, it is indeed typical of the *linearis* Zone as described here and the importance of *Climacograptus styloideus* in recognizing the zone has been emphasized by Bulman (1958: 169).

I do not consider the *complanatus* Zone fauna to be dwarfed or pathological; indeed the zone fossil is more widely distributed than *Dicellograptus anceps*. The unfortunate fact about the zone is that it is based solely on a thin band in an otherwise barren sequence, and as the band is so near (1.5–1.8 m. above) to the *linearis* Zone it could be argued that it should be included in that zone (Elles 1937). However, Dr. Ingham has kindly loaned me material from the Upper Whitehouse Formation of the Girvan area, and this horizon contains abundant *D. complanatus*, as originally indicated by Lapworth (1882), some of which (Text-fig. 4b) are identical with those figured here from Dobb's Linn (Text-figs. 2g–l), and others have a smaller axial angle and appear intermediate between *D. complanatus* and *D. anceps*. There also occurs at this horizon *D. ornatus minor* subsp. nov., a form characteristic of the *anceps* Zone at Dobb's Linn. Thus at Girvan we have intermingling of the Dobb's Linn *anceps* and *complanatus* Zone faunas, and Girvan is providing faunas from a level equivalent to the Barren Mudstones at Dobb's Linn above the *complanatus* Band and below the *anceps* Zone, where it is possible that (if the beds were fossiliferous) the ranges of *D. anceps* and *D. complanatus* overlap. The probability that a more detailed graptolite sequence may yet come out of the Girvan sequence at this level is reason enough for provisional retention of the *complanatus* Zone.

The status of the *P. linearis* Zone is on much surer ground, but the present description of the fauna has provided some interesting results, most important of which concern the vertical restriction of *Leptograptus capillaris* and the zone fossil and the abundance of *Dicellograptus pumilus* and *D. morrisoni* at the very top of the zone. No dicranograptids occur at all, the presence of these indicating the *D. clingani* Zone or lower. In the absence of the zone fossil *Leptograptus capillaris* and *Climacograptus styloideus* are very characteristic of the zone. In Dr. Ingham's collections from Girvan *P. linearis* occurs at the very top of the Lower Whitehouse Formation. In Northern Ireland it has been recorded by Clark (1902) and Pollock & Wilson (1961). Elsewhere in the world *P. linearis* is rare but has been recorded from Australia (Sherrard 1954, Thomas 1960), and a single specimen from North America (Ruedemann 1947).

IV. THE CARADOC-ASHGILL BOUNDARY IN THE GRAPTOLITIC SEQUENCE

The *P. linearis* Zone is generally accepted as being the highest division of the Caradoc Series in the graptolitic sequence, and the zones of *D. complanatus* and *D. anceps* are usually equated to the whole of the Ashgill Series (Whittard 1960).

Exact correlations between graptolitic and shelly facies of the upper Ordovician have always been controversial because of the lack of graptolites in the classic shelly Caradoc and Ashgill sequences of Wales, the Welsh Borders and the Lake District. However the Girvan area does provide a mixed shelly and graptolitic fauna at these horizons, and the following discussion is based entirely on material kindly loaned me by Dr. Ingham who is actively working on the upper Ordovician trilobites of the area.

As stated earlier, Mrs. Gray recorded *D. anceps* from the Drummuck Group of the Craighead Inlier (Peach and Horne 1899 : 525) and Dr. Ingham has now obtained two good specimens from the higher part of the Shalloch Formation (=Barren Flagstones) which underlies the Drummuck Group. Ingham also (1966 : 473) obtained *D. anceps* from the Middle Ashgill of Cautley and suggested (1966 : 488) that the lowest Ashgill at Cautley should, on the evidence of trilobite faunas, be equated with the Lower Drummuck Group of Girvan. Thus if the latter is basal Ashgill it overlies beds (the Shalloch Formation) which contain *D. anceps*, and thus the Ashgill Series is only represented by the upper part of the *anceps* Zone.

Dr. Ingham's preliminary studies of the trilobite faunas of the Upper Whitehouse and lower Shalloch Formations seem to confirm this, for they show Pusgillian (highest Caradoc) affinities, and yet contain *D. complanatus*, *D. anceps* and *D. ornatus minor* indicating the *complanatus* and *anceps* Zones. If the Pusgillian is accepted as the highest stage of the Caradoc Series it is thus equivalent not only to part of the *linearis* Zone (Dean 1959 : 149), but the whole of the *complanatus* Zone (as originally suggested by Bancroft in 1945), and extends up into the base of the *anceps* Zone. The Caradoc-Ashgill boundary thus lies at some level in the *D. anceps* Zone, and this is the highest level in the graptolitic sequence so far suggested for this boundary.

V. SYSTEMATIC DESCRIPTIONS

Suborder DIDYMOGRAPTINA Lapworth 1880 (emend. Bulman 1963)

Family **DICRANOGRAPTIDAE** Lapworth 1873

Genus **DICELLOGRAPTUS** Hopkinson 1871

Dicellograptus anceps (Nicholson)

(Pl. 2, Pl. 3, figs. 2-7; Text-figs. 2a-f, 4a)

1867 *Didymograpsus anceps* Nicholson: 110, pl. 7, figs. 18-20.

1870 *Didymograpsus anceps* Nicholson: 351, pl. 7, fig. 5.

1871 *Dicellograpsus anceps* (Nicholson); Hopkinson: 335, pl. 1, figs. 5a-b.

1876 *Dicellograptus anceps* (Nicholson); Lapworth: pl. 4, fig. 82.

1877 *Dicellograptus anceps* (Nicholson); Lapworth: pl. 7, fig. 5.

1890 *Dicellograptus anceps* (Nicholson); Törnquist: 21-23, pl. 2, figs. 16-19.

1904 *Dicellograptus anceps* (Nicholson); Elles and Wood; 141-143, pl. 20, figs. 3a-e.

DIAGNOSIS. Stipes rigid, with relatively short and wide climacograptid thecae bearing mesial spines and having slight introversion, opening into deep excavations, numbering 10-8 in 10 mm. Stipes up to 1.5 mm. wide. Axial region sharply angled or rounded, axial angle 10°-30°, sometimes parallel sided. Sricula and virgella rarely preserved.

LECTOTYPE. Q 3047, Nicholson Collection, Dobb's Linn, Moffat. ?Figured Nicholson 1867, pl. 7, fig. 19. Nicholson's graptolite collection was purchased by the B.M. (N.H.) in 1883 and it contains twelve specimens of *D. anceps*. Of these Q 3047 and Q 3065 could be the originals of his Pl. 7, figs. 19, 20, but it is impossible to be certain. Assuming the collection to be his original syntypes, a lectotype has been selected from them.

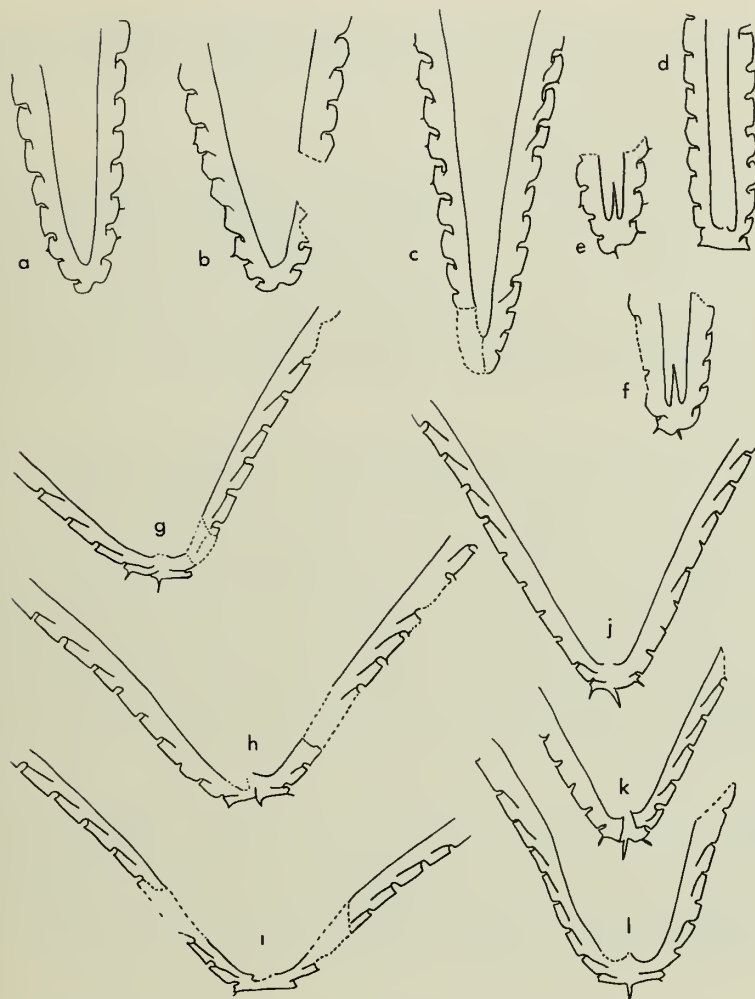


FIG. 2. a-f, *Dicellograptus anceps* (Nicholson), *anceps* Zone, Dobb's Linn, Moffat, Scotland, $\times 6$. a, lectotype, Q3047, Nicholson Collection; b, paralectotype, Q3065; c, Q2753; d, Q2784; e, Q2857c; f, Q2857b. g-l, *Dicellograptus complanatus* Lapworth, *complanatus* Band, Dobb's Linn, Moffat, Scotland, $\times 6$. g, lectotype, BU1072b, Lapworth Collection, fig'd Elles & Wood, 1904, pl. 20, fig. 1b; h, BU1072d; i, BU1072c, fig'd Elles & Wood, pl. 20, fig. 1d; j, Q2868a, Author's Collection; k, counterpart of Q2868a; l, Q2868b.

MATERIAL. The Nicholson Collection and twenty specimens collected by the author from the *anceps* Zone, Dobb's Linn, Moffat.

DESCRIPTION. The stipes are often long, up to 60 mm. and generally straight and rigid, but occasionally flexed either convex or concave. The axial region is typically sharply angled (Pl. 3, fig. 7), but is sometimes more rounded (Pl. 3, figs. 2, 5, 6),

and the axial angle is typically 20°–30°, but occasionally the stipes are parallel-sided (Pl. 3, figs. 2, 5). The stipes appear quite robust increasing in width from 0.5–0.8 mm. at the axial region to a maximum of 1.5 mm. The sicula is rarely preserved (hence the specific name), but when found (Pl. 2, figs. 6, 7; Text-figs. 2e, f) is 1.6 mm. long with a short virgella.

The thecae increase in length from 1.2 to 1.6 mm., number 10–8 in 10 mm., and overlap 1/3. They are of the climacograptid type with a conspicuous, but rounded, geniculum, and the free ventral wall shows continuous slight convex curvature, and the apertural region is slightly introverted opening into a deep excavation (Pl. 2, fig. 1). The apparent isolate apertures seen in Text-fig. 2c are due to a thin film of matrix. The thecae are relatively broad being about 5 times as long as wide. The proximal thecae bear a small spine midway along the free ventral wall, and the base of this is quite massive, and gives the thecae a double angled appearance (Text-fig. 2a).

REMARKS. This is the youngest dicellograptid to occur in any abundance. The variations in the orientation of the stipes have not been noted before.

ASSOCIATES AND OCCURRENCE. The species occurs commonly in all the four fossiliferous horizons of the *anceps* Zone at Dobb's Linn (Text-fig. 1), associated with all the fauna of the zone. It occurs at Girvan in the Drummuck Group (Peach & Horne 1899: 525), and Dr. Ingham has collected it from the underlying Shalloch Formation (=Barren Flagstones) (Text-fig. 4a). He also recorded the species from the Middle Ashgill of Cautley (Ingham 1966: 473). Although recorded from Wales (Jones 1909; Pugh 1923) specimens are not well preserved. In Northern Ireland it was recorded from Coal Pit Bay by Clark (1902), and Pomeroy (Fearnside, Elles and Smith 1907) and has recently been collected by the Geological Survey in the Belfast area.

The species occurs in the Upper *Dicellograptus* Shales of Sweden (Törnquist 1890) but Skoglund (1963: 32) considered that the specimens identified by Törnquist (1890) as *D. anceps* were compressed specimens of *D. morrisoni*. Although recorded from Australia (Hall 1898; Thomas 1960) it has not been figured, and there is only one very doubtful record from North America (Ruedemann 1947: 376).

Dicellograptus complanatus Lapworth

(Pl. 4, 5, 6, fig. 1; Text-figs. 2g–l, 4b)

- 1880 *Dicellograptus complanatus* Lapworth; 160–161, pl. 5, figs. 17a–e.
 1904 *Dicellograptus complanatus* Lapworth; Elles and Wood: 139–140, pl. 20, figs. 1a–d.
 ?1937 *Dicellograptus* cf. *complanatus* Lapworth; Sherrard and Keble: 309, fig. 8.
 ?1938 *Dicellograptus* cf. *complanatus* Lapworth; Harris and Thomas; pl. 3, fig. 103.
 1947 *Dicellograptus complanatus* Lapworth; Ruedemann: 376, pl. 62, figs. 4–10.
 1947 *Dicellograptus complanatus* var. *tenuis* Ruedemann: 378.
 1960 *Dicellograptus complanatus* Lapworth; Berry: 73, pl. 20, fig. 1.
 ?1963 *Dicellograptus complanatus* Lapworth; Churkin: 63, fig. 39.
 1963 *Dicellograptus complanatus* Lapworth; Skoglund: 33–36, text-fig. 10, pl. 1, fig. 3.

DIAGNOSIS. Slender stipes with climacograptid thecae with little or no introver-

sion and straight supragenicular walls, numbering 8–12 in 10 mm. Stipes generally straight, up to 1 mm. wide and often up to 80 mm. long, axial angle 50°–90°. Sicula rarely preserved, virgella conspicuous but short, first two thecae bearing short mesial spines.

LECTOTYPE. BU1072b. The specimen figured, Elles and Wood, 1904, pl. 20, fig. 1b. Base of "Barren Mudstones", Dobb's Linn, Moffat, Lapworth Collection.

BU1072 is probably Lapworth's type slab and contains three specimens figured by Elles and Wood. However none of these, or any others on the slabs, can be matched exactly with Lapworth's original drawings, and so a lectotype has been selected from what may safely be considered his original syntypes.

MATERIAL. Lapworth's original collection (10 slabs), one figured specimen from the Wood Collection, and fifteen other specimens collected by the author. All from the *complanatus* Band, *complanatus* Zone, Main Cliff, Dobb's Linn, Moffat.

DESCRIPTION. The stipes are often very long, up to 80 mm., and generally straight, but occasionally flexed outwards at the proximal end (Pl. 4, fig. 4, Pl. 6, fig. 1).

The axial region is either rounded and open (Pl. 5, figs. 1, 3), or angled (Pl. 5, figs. 2, 4), and the axial angle is usually between 50°–90°, but increases to much more when double curvature occurs. Some of these variations in the axial region are probably due to distortion. The stipes are generally narrow increasing gradually in width from 0.4–0.6 mm. at the axial region to a maximum of 1 mm. The sicula is rarely preserved but is about 1.5 mm. long (Pl. 4, fig. 3), and a short but conspicuous virgella is always present. The first two thecae are relatively short (1 mm.) and grow horizontally, each bearing a short mesial spine. Later thecae are 1.5–1.6 mm. long and show a characteristic climacograptid appearance, with a very pronounced geniculum, which shows secondary thickening, giving the appearance of a small flange in profile view (Text-fig. 2h). The free ventral wall of each theca is generally parallel to the dorsal margin of the stipe, but in some cases there is slight introversion. The thecae overlap 1/3–1/2, number 10–8 in 10 mm., occasionally 12, but the latter figure is probably due to distortion.

REMARKS. This is a very distinct species, which may have developed from either *D. morrissi* (Hopkinson) or *D. forchammeri* (Geinitz), both of which it resembles somewhat, but is distinguished by its simple climacograptid thecae with no introversion. Specimens from Girvan sometimes appear intermediate between *D. complanatus* and *D. anceps*, and these forms occur at a level probably higher than the *complanatus* Band at Dobb's Linn. Ruedemann (1947: 377) distinguished a var. *maximus* which had stipes 2.2 mm. wide with 6 thecae in 10 mm. No stipes wider than 1 mm. have been found at Dobb's Linn.

OCCURRENCE AND ASSOCIATES. At Dobb's Linn, *D. complanatus* is associated with crowds of *Orthograptus truncatus socialis* and *Climacograptus scalaris miserabilis* and is restricted to the *complanatus* Band. I have been unable to find the *complanatus* Band anywhere else in the Moffat area. Lapworth (1878: 270) stated it occurred at Moory Syke but I have not been able to confirm this, and although the Barren Mudstones are well exposed at Craigmichan Scaurs and Belcraig Burn, they contain no fossiliferous horizons (Lapworth 1878: 263, 284).

At Girvan *D. complanatus* occurs throughout the Upper Whitehouse Formation (Lapworth 1882) and in Dr. Ingham's collection is associated rarely with *D. ornatus minor* subsp. nov. in the highest beds of the formation. It has been recorded from Northern Ireland (Lapworth 1880 : 161; Fearnside, Elles and Smith 1907) although not figured. Elsewhere in Europe, it occurs only in Sweden, in the Upper *Dicellograptus* Shales (Törnquist 1881, 1914, Tullberg 1882, Tornebohm and Henning 1904, Moberg 1911, Skoglund 1963). The latter author gave an account of the development of *D. complanatus* based on pyritized material.

D. complanatus occurs widely in North America (Ruedemann 1947, Berry 1960, Churkin 1963). It also occurs in Victoria and New South Wales, Australia (Thomas 1960), but the only figured specimens (Sherrard and Keble 1937; Harris and Thomas 1938) are referred to *D. cf. complanatus*.

Dicellograptus ornatus Elles & Wood

(Pl. 6, figs. 2-4; Text-figs. 3a, b)

- 1904 *Dicellograptus complanatus ornatus* Elles & Wood: 140-141, pl. 20, figs. 2a, b. non. fig. 2c.
 1906 *Dicellograptus complanatus ornatus* Elles & Wood; Hall: 273, pl. 34, fig. 3.
 1947 *Dicellograptus complanatus ornatus* Elles & Wood; Ruedemann: 377-378, pl. 62, figs. 16-20.
 1960 *Dicellograptus complanatus ornatus* Elles & Wood; Berry: 74, pl. 20, fig. 3.
 1963 *Dicellograptus complanatus ornatus* Elles & Wood; Churkin: pl. 3, fig. 40.
 1963 *Dicellograptus complanatus ornatus* Elles & Wood; Ross and Berry: 103-104, pl. 6, figs. 8, 12, 13, 17, 19.

DIAGNOSIS. Slender dicellograptid with introverted and ?introtorted thecae numbering 10-11 in 10 mm. Stipes straight up to 0.6 mm. wide and 60 mm. long, axial region square, axial angle 30°-40°. Sicula and virgella rarely preserved. First two thecae characterized by long and robust (?apertural) spines

LECTOTYPE. SMA19332. Figured as *D. complanatus ornatus*, Elles & Wood, 1904, pl. 20, fig. 2b. *anceps* Zone, Dobb's Linn, Moffat.

MATERIAL. The lectotype and one other paralectotype.

DESCRIPTION. The stipes are long, up to 60 mm. and generally straight and narrow, widening gradually from 0.4 to 0.6 mm. The axial region is typically square and the axial angle 30°-40°. The sicula and virgella are not seen in either of the specimens. The first two thecae bear very conspicuous stout spines up to 4.2 mm. long, but it cannot be said with certainty whether these are apertural or mesial as they have coalesced with the whole of the theca, and it is impossible to pick out the aperture of the first two thecae. The remaining thecae are 1.2 to 1.5 mm. long and show marked introversion, narrowing, and possibly introtortion of the apertural region. The free ventral wall of each thecae is gently convex and a geniculum is well seen on the left hand distal thecae of the lectotype (Text-fig. 3a). The thecae overlap 1/3 and number 11-10 in 10 mm.

REMARKS. The thecal form bears no resemblance to *D. complanatus* and so Elles and Wood's variety *ornatus* is considered as a distinct species. The thecal form is in

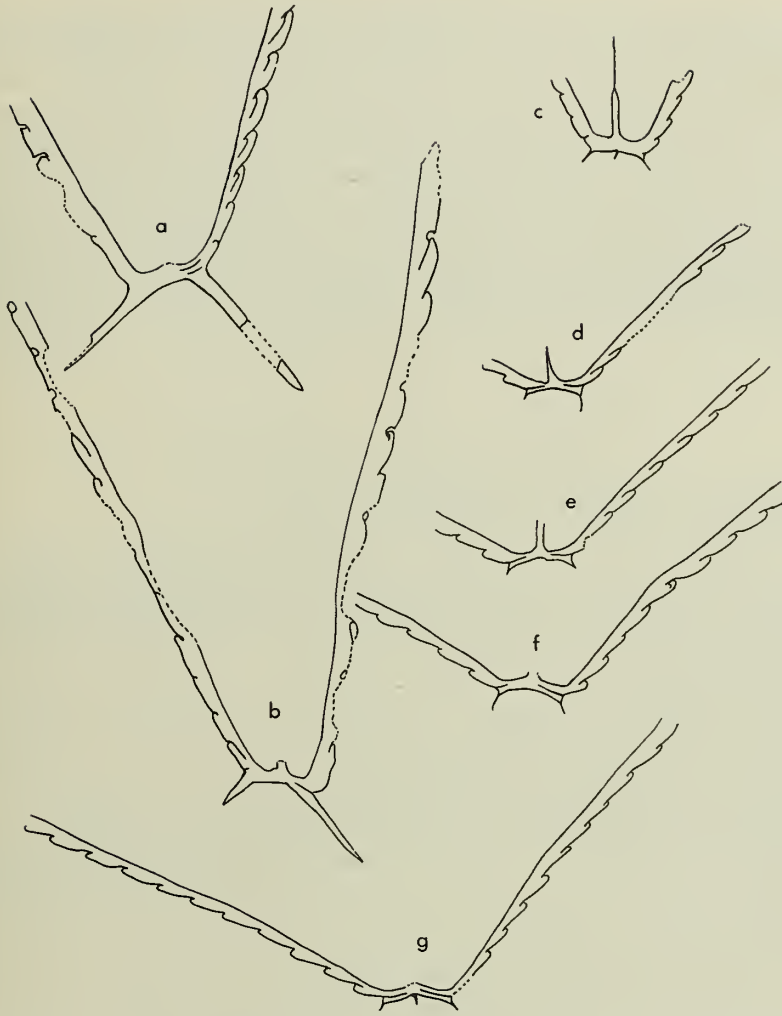


FIG. 3a-b, *Dicellograptus ornatus* Elles & Wood, *anceps* Zone, Dobb's Linn, Moffat, Scotland, $\times 6$. a, lectotype, SM A19332, fig'd as *D. complanatus ornatus*, Elles & Wood, 1904, pl. 20, fig. 2b; b, paralectotype, SM A19331a, fig'd as *D. complanatus ornatus*, Elles & Wood, 1904, pl. 20, fig. 2a. c-g, *D. ornatus minor* subsp. nov., *anceps* Zone, Dobb's Linn, Moffat, $\times 6$. c, Q3066, Nicholson Collection, ?fig'd as *Didymograptus flaccidus* (Hall), Nicholson, 1867, pl. 7, fig. 3; d, Q2766a; e, Q2766b; f, holotype, SM A19333, fig'd as *D. complanatus ornatus*, Elles & Wood, 1904, pl. 20, fig. 2c; g, Q2766c.

fact more like *D. forchammeri* (Geinitz). In describing specimens from North America both Ruedemann (1947) and Berry (1960) remarked on the exact similarity of their specimens with the descriptions of Elles and Wood, and yet I am suggesting that the latter's description was incorrect. I have examined specimens in collections

of the U.S. Geological Survey collected by Dr. Churkin from Alaska, and Idaho, and these specimens have much larger spines than the British forms, up to 8 mm. long. However the thecal form agrees with the description given above.

OCCURRENCE AND ASSOCIATES. *D. ornatus* is rare in the *anceps* Zone at Dobb's Linn and the only two specimens are associated with *Climacograptus supernus* and *Orthograptus truncatus abbreviatus*. In Britain it only occurs at Dobb's Linn, but even more spinose forms are characteristic of the highest Ordovician of North America. These horizons are there termed the *D. complanatus* or *D. complanatus ornatus* Zone (Ruedemann 1947, Churkin 1963, Jackson and Lenz 1962, Jackson, Steen and Sykes 1965, Ross and Berry, 1963). The species is also recorded from Australia (Hall 1906, Harris and Keble 1933, Thomas 1960).

***Dicellograptus ornatus minor* subsp. nov.**

(Pl. 6, figs. 5-7; Text-figs. 3c-g)

?1867 *Didymograpsus flaccidus* (Hall); Nicholson: pl. 7, fig. 3.

1904 *Dicellograptus complanatus ornatus* Elles & Wood: pl. 20, fig. 2c.

?1947 *Dicellograptus complanatus arkansasensis* Ruedemann: 377, pl. 62, figs. 11-15.

DIAGNOSIS. Very slender dicellograptid with introverted and ?introtorted thecae numbering 11-12 in 10 mm. Stipes straight up to 0.5 mm. wide, axial region square, axial angle 100°-120°. Sicula and virgella conspicuous. First two thecae bearing very short apertural spines.

HOLOTYPE. SMA19333, figured as *D. complanatus ornatus*, Elles & Wood, 1904, pl. 20, fig. 2c. *anceps* Zone, Dobb's Linn, Moffat.

MATERIAL. The holotype, five specimens collected by the author, and one specimen from the Nicholson Collection. All from the *anceps* Zone, Dobb's Linn.

DESCRIPTION. The stipes are generally short, straight, and very narrow, but one fragment (Pl. 3, fig. 1) 60 mm. long may be referable to this subspecies. The stipes widen from 0.2 mm. to a maximum of only 0.5 mm. The axial region is open and the first two thecae grow slightly downwards, rather than horizontal, so that the axial region has a slightly deflexed appearance (Text-figs. 3f, g). The axial angle is between 80°-120°. The sicula is well preserved on three of the specimens and is 1.5 mm. long with a conspicuous, but short virgella. One specimen bears a nema 1.5 mm. long. The first two thecae each bear a short apertural spine and are of a simple, almost leptograptid type. In most cases the spines are no more than small denticles on the ventral wall. The remaining thecae are 1.0-1.2 mm. long, overlap 1/3, number 11-12 in 10 mm., and have the same introversion of the apertural region as in *D. ornatus*.

REMARKS. This subspecies has all the characters of *D. ornatus* but is less robust and lacks the proximal spines. In overall appearance it approaches species of *Leptograptus*, and also shows some resemblance to *Dicellograptus angulatus* Elles & Wood (1904: 150, figs. 3a-c), but this is supposedly a much earlier species. The specimen from the Nicholson Collection (Text-fig. 3c) occurs in association with *Dicellograptus anceps* and *Orthograptus truncatus abbreviatus*, and is quite probably that figured by

Nicholson (1867, pl. 7, fig. 3) as *Didymograpsus flaccidus*. *D. complanatus arkan-sasensis* (Ruedemann 1947: 377, pl. 62, figs. 11-15), is said to be identical with *D. ornatus* but lacks the basal spines, so that it would on this evidence appear as *D. ornatus minor*. However, Ruedemann's figures show a much smaller axial angle and his variety is here only tentatively equated with *D. ornatus minor*.

OCURRENCE AND ASSOCIATES. The subspecies is rare and restricted to the *anceps* Zone at Dobb's Linn, where it occurs with *D. anceps*, *Climacograptus supernus* and *Orthograptus truncatus abbreviatus*. Dr. Ingham has collected a specimen from the Upper Whitehouse Formation at Girvan, associated with *Dicellograptus complanatus*. I have recently examined two specimens from the Belfast area collected by the Geological Survey, and although referred to this subspecies, they are even more slender reaching a maximum width of only 0.25 mm.

Dicellograptus moffatensis (Carruthers)

(Pl. 8, Pl. 9, figs. 4, 5)

1858 *Didymograpsus Moffatensis* Carruthers: 469, fig. 3.

1904 *Dicellograptus moffatensis* (Carruthers): Elles & Wood: 157, pl. 23, figs. 1a-f.

1969 *Dicellograptus moffatensis* (Carruthers); Strachan: 189-190, text-fig. 2c, pl. 3, figs. 5, 6.

The type material of this species has recently been redescribed by Strachan (1969). The specimens here referred to the species *D. moffatensis* lack the membrane surrounding the axial region, but agree with Strachan's description in other features. It is the most robust of all the dicellograptids reaching a width of 1.5 mm.

At Dobb's Linn it occurs in the *linearis* Zone associated with *D. carruthersi* sp.nov., *D. morrissi*, and *Orthograptus truncatus*. This is the highest level from which it has been recorded as Elles & Wood (1904: 159) recorded it only from the much lower zones of *N. gracilis* and *C. wilsoni*.

Records from even lower horizons are not genuine (Strachan 1969: 190).

Dicellograptus morrissi Hopkinson

(Pl. 7, figs. 1-4; Text-figs. 4d-f)

1871 *Dicellograpsus Morrissi* Hopkinson: 24, pl. 1, figs. 2a-h.

1876 *Dicellograptus Morrissi* Hopkinson; Lapworth: pl. 4, fig. 85.

1904 *Dicellograptus Morrissi* Hopkinson; Elles & Wood: 155-157, pl. 21, figs. 6a-d.

1963 *Dicellograptus morrissi* Hopkinson; Skoglund: 31-32, pl. 1, figs. 1, 2.

DIAGNOSIS. Dicellograptid with long rigid stipes widening throughout their length to 1.3 mm. Thecae numbering 12-10 in 10 mm. showing a rounded geniculum and marked introversion. Axial region rounded and open, axial angle 70°-80°. Sicular rarely preserved.

MATERIAL. Numerous specimens, all from the top of the *linearis* Zone, Dobb's Linn, Moffat.

DESCRIPTION. The stipes are often long, up to 50 mm. and generally straight and rigid, but occasionally show slight concave curvature (Pl. 7, fig. 1c). The axial region is usually rounded and open, and the axial angle typically 70° – 80° . The stipes increase in width gradually but persistently from 0.4 mm. to a maximum of 1.2 mm. The sicula is rarely preserved but is about 1.3 mm. long (Text-fig. 4d) with a short virgella. The thecae increase in length from 1.2 to 1.5 mm., are relatively long and narrow, number 12–10 in 10 mm. and overlap $1/3$. They show flowing sigmoid curvature of the ventral wall, with a rounded geniculum, and with a markedly introverted apertural region, opening into a deep excavation. The first two thecae bear short (?apertural) spines.

REMARKS. The persistent widening of the stipes is very characteristic of this species, and the thecal form is similar to *D. ornatus*. It is possible that *D. pumilus* Lapworth is in fact a young stage of *D. morrisi*. Skoglund (1963 : 32) stated that the proximal thecae (up to the 11th pair) bear stout mesial spines, but none of the specimens here described show this feature. He also stated that when obliquely compressed *D. morrisi* resembles *D. anceps* and suggested that specimens assigned to *D. anceps* by Törnquist (1890) were in fact distorted specimens of *D. morrisi*. I cannot see how any of the specimens here described as *D. morrisi* could appear as *D. anceps*.

OCCURRENCE AND ASSOCIATES. The species is abundant in the highest 0.3 m. of the *linearis* Zone at Dobb's Linn associated with *D. pumilus* (Pl. 7).

Dicellograptus carruthersi sp. nov.

(Pl. 7, figs. 5, 6; Text-fig. 4c)

DIAGNOSIS. Stipes rigid, up to 45 mm. long and 0.8 mm. wide. Thecae 12–10 in 10 mm. with marked introversion. Axial region sharply angled, axial angle 30° .

HOLOTYPE. Q 2915, *linearis* Zone, Dobb's Linn, Moffat.

MATERIAL. Numerous specimens all in the Author's Collection.

DESCRIPTION. The stipes are straight, rigid, and up to 45 mm. long, gradually increasing in width from 0.4 to 0.8 mm. The axial region is sharply angled and the axial angle typically 30° , but sometimes greater. The sicula is rarely preserved but has a short virgella, and the first two thecae bear mesial spines. The thecae are 1.2 mm. long, relatively narrow, overlap $1/2$, number 12–10 in 10 mm. and show marked sigmoid curvature of the ventral wall, and introversion of the apertural region. They are of the same type as *D. morrisi*.

REMARKS. This new species is similar to *D. morrisi* but is narrower and has a much smaller axial angle.

OCCURRENCE AND ASSOCIATES. The species is common in the *linearis* Zone at Dobb's Linn, particularly in the highest 0.3 m., associated with *D. moffatensis*, *D. morrisi*, and *D. pumilus*.

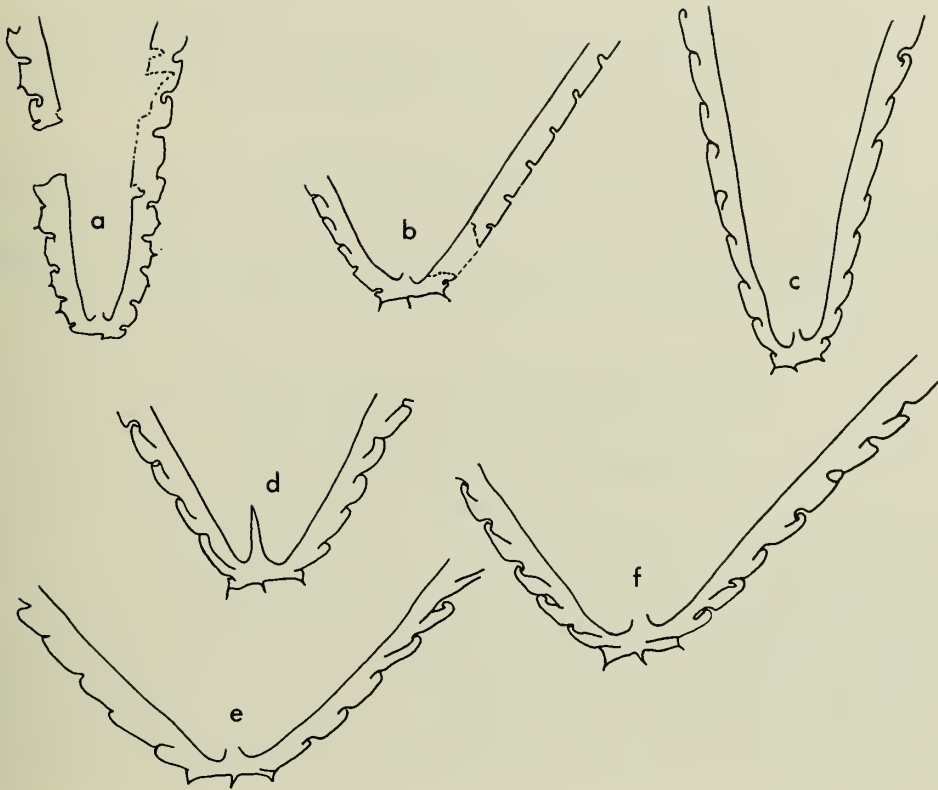


FIG. 4a, *Dicellograptus anceps* (Nicholson), HM.C802/1, Shalloch Formation (=Barren Flagstones), Woodland Point, Girvan, Ingham Collection, $\times 6$. b, *Dicellograptus complanatus* Lapworth, HM.C785/1b, Upper Whitehouse Formation, Girvan, Ingham Collection, $\times 6$. c, *Dicellograptus carruthersi* sp. nov., holotype, Q2915, $\times 6$, *linearis* Zone, Dobb's Linn, Moffat. d-f, *Dicellograptus morrissi* Hopkinson, top of *linearis* Zone, Dobb's Linn, Moffat, $\times 7$, d, Q2905a; e, Q2904b; f, Q2904a.

Dicellograptus cf. *elegans* (Carruthers)

(Plate 9, figs. 1-3)

1867 *Didymograptus elegans* Carruthers: 369, pl. 2, fig. 16a.

1904 *Dicellograptus elegans* (Carruthers); Elles & Wood: 159, pl. 23, figs. 2a-e.

1969 *Dicellograptus elegans* (Carruthers); Strachan: 187-8, text-figs. 2a, b, pl. 3, fig. 1.

The type specimen of this species has recently been redescribed by Strachan (1969), and the most conspicuous feature of the species is the marked change in curvature of the stipes which (Strachan 1969: 188) "curve first upwards, then outwards, then upwards again".

The specimens here referred to *D.* cf. *elegans* do not show the final upward curve

of the typical form, only showing one outward curve 3–4 mm. along the stipes. The thecae however have the characteristic marked introversion of the apertural region, but are closer together (12–10 in 10 mm.), as compared with 10–8 in 10 mm. in the typical form. The stipes reach 0.8 mm. in width which is rather less than the maximum of 1 mm. in the holotype.

These specimens are intermediate between *D. elegans* and *D. elegans rigens* Elles & Wood, a subspecies with rigid stipes. One specimen (Pl. 9, fig. 3) is referred to this latter form.

OCCURRENCE AND ASSOCIATES. *D. cf. elegans* and *D. cf. elegans rigens* occur rarely in the *linearis* Zone with *Orthograptus truncatus pauperatus*.

Family **LEPTOGRAPTIDAE** Lapworth 1880

Genus **PLEUROGRAPTUS** Nicholson 1867

Pleurograptus linearis (Carruthers)

(Pl. 10, figs. 1, 2, 4)

1858 *Cladograptus linearis* Carruthers: 467, fig. 1.

1903 *Pleurograptus linearis* (Carruthers); Elles & Wood: pl. 16, fig. 7; pl. 17, figs. 1, 2.

1969 *Pleurograptus linearis* (Carruthers); Strachan: 186–7, text-fig. 1, pl. 2.

The type material of this species has recently been reviewed by Strachan (1969) and it is not intended to add to that description.

P. linearis has been found to be restricted to a level of 1.5–1.8 m. below the top of the *linearis* Zone where it occurs commonly, associated with *Leptograptus flaccidus*. A single specimen of *P. linearis simplex* has been found at a level 0.3 m. above the *P. linearis* horizon.

Genus **LEPTOGRAPTUS** Lapworth 1873

Leptograptus capillaris (Carruthers)

(Pl. 10, fig. 3)

1868 *Cladograptus capillaris* Carruthers: 130, pl. 5, figs. 7, 7a.

1903 *Leptograptus capillaris* (Carruthers); Elles & Wood: 112, pl. 15, figs. 4a–d.

1969 *Leptograptus capillaris* (Carruthers); Strachan: 185–6, pl. 1.

The type specimen of this species has recently been reviewed by Strachan (1969). At Dobb's Linn it is restricted to a level 0.9 m. below the top of the *linearis* Zone where it occurs in abundance on one bedding plane with no associates.

Suborder DIPLOGRAPTINA Lapworth 1880 (emend Bulman 1963)

Family **DIPLOGRAPTIDAE** Lapworth 1873

Genus **GLYPTOGRAPTUS** Lapworth 1873

Glyptograptus nicholsoni sp. nov.

(Pl. 15, fig. 3)

DIAGNOSIS. Glyptograptid with short and markedly alternate thecae, which are closely set (16–13 in 10 mm.), and which show a marked distal decrease in overlap.

HOLOTYPE. Q2757. The only specimen, *anceps* Zone, Dobb's Linn.

DESCRIPTION. The only specimen found has a rounded, blunt, proximal end and increases gradually in width from 1.0 mm. to 1.4 mm. after 12 mm. The sicula is not visible. The thecae are relatively short, increasing in length from 0.8 mm. to 1.3 mm. and are closely set (16 in 10 mm.) at the proximal end but this value decreases distally to 13. They show flowing sigmoid curvature with a rather insignificant geniculum and are not far from being referable to *Orthograptus*. The thecae are markedly alternate, inclined at 25°, overlapping $\frac{1}{2}$ at the proximal end but the amount of overlap decreases sharply towards the distal end where they overlap only $\frac{1}{4}$, and here the thecae appear even more alternate.

REMARKS. This new species is the first glyptograptid to be described from the British higher Ordovician. It could be the ancestor of *G. persculptus* (Salter) or *G. avitus* Davies, but is closer to some of the Llandovery species described by Packham (1962).

It occurs in the *D. anceps* Zone associated with *D. anceps* and *Climacograptus supernus*.

Genus **DIPLOGRAPTUS** M'Coy 1850

Diplograptus fastigatus (Davies)

(Pl. 14)

1929 *Orthograptus fastigatus* Davies: 4, figs. 3–5.

DISCUSSION. Davies (1929: 4) remarked on the differences between the proximal and distal thecae stating that the proximal thecae showed a pronounced curvature of the ventral wall, whereas the distal thecae were typical of *Orthograptus*.

The proximal thecae in fact show a climacograptid appearance (Pl. 14, fig. 5) and on this evidence the species is referred to *Diplograptus* s.s. It is abundant in, but restricted to, the *anceps* Zone.

Genus *CLIMACOGRAPTUS* Hall 1865

Climacograptus hvalross Ross & Berry

(Pl. 11, figs. 1-4, 7)

1963 *Climacograptus hvalross* Ross and Berry: 124, pl. 8, figs. 19, 26, 27.

DISCUSSION. This is the first time that this species, first recorded from the highest Ordovician (*D. complanatus* Zone) of Nevada and Idaho, has been recorded elsewhere. The specimens here referred to it show all the characteristics described by the original authors including the membrane surrounding the initial parts of the conspicuous basal spines (Pl. 11, fig. 2). It is restricted to the *D. anceps* Zone associated with *D. anceps* and *Climacograptus supernus*.

Climacograptus supernus Elles & Wood

(Pl. 11, figs. 5, 6, 8-10)

1906 *Climacograptus supernus* Elles & Wood: 196-197, pl. 26, figs. 11 a-d.

DISCUSSION. This species is restricted to the *D. anceps* Zone where it occurs quite commonly, associated with *C. latus* and *C. hvalross*. The slender basal spines are very characteristic as well as the slight temporary decrease in width after the first thecal pair.

Climacograptus latus Elles & Wood

(Pl. 15, figs. 1, 2)

1906 *Climacograptus latus* Elles & Wood: 204-205, pl. 27, figs. 3a-h.

DISCUSSION. This rare species in the *D. anceps* Zone has only been recognized on distal fragments. These have a maximum width of 2.2 mm. and the thecae number 14-12 in 10 mm. Pl. 15, fig. 2 shows the characteristic rapid widening of the proximal portion although the extreme proximal end is missing.

Climacograptus styloideus Elles & Wood

(Pl. 13, figs. 1-4, 6)

1878 *Climacograptus styloideus* Lapworth: 312 (nomen nudum).

1906 *Climacograptus styloideus* Lapworth MS; Elles & Wood: 205-206, pl. 27, figs. 9a-e.

1963 *Climacograptus styloideus* Elles & Wood; Skoglund: 38-40, pl. 2, figs. 1-4, pl. 3, fig. 3.

DISCUSSION. This species occurs quite commonly in, but is restricted to, the *P. linearis* Zone, where it is very characteristic and associated with *Dicellograptus morrissi* and *D. carruthersi*.

According to Lapworth (1878: 312) a band with *C. styloideus* characterized the upper part of the *Dicranograptus clingani* Zone, but I have been unable to find this

species lower than the *linearis* Zone. Elsewhere in the world *C. styloideus* is considered a good indicator of the *linearis* Zone in the absence of the zone fossil (Bulman 1958 : 169).

***Climacograptus scalaris miserabilis* Elles & Wood**

(Pl. 12)

non 1895 *Diplograptus* (*Glyptograptus*) *euglyphus* var. *angustus* Perner: 27, Pl. 8, figs. 14a, b.

1906 *Climacograptus scalaris* var. *miserabilis* Elles & Wood: 186-187, pl. 26, figs. 3a-h.

1963 *Climacograptus angustus* (Perner); Skoglund: 40-42, pl. 3, figs. 1, 2, pl. 4, fig. 7, pl. 5, fig. 6.

DISCUSSION. Skoglund (1963 : 40) considered *C. scalaris miserabilis* Elles & Wood to be a junior homonym of *C. angustus* (Perner 1895). I do not agree with this, but I am sure that *C. angustus* (Perner) Skoglund 1963 is identical with *C. scalaris miserabilis* Elles & Wood though not the same as *C. angustus* (Perner 1895). The material on which Elles & Wood based their definition came from the *complanatus* Band at Dobb's Linn where it occurs in abundance. The very thin periderm and "ghost-like" appearance of the specimens from this horizon is very characteristic. It also occurs rarely in the *linearis* and *anceps* Zones, and ranges up into the basal Silurian.

Genus **ORTHOGRAPTUS** Lapworth 1873

***Orthograptus quadrimucronatus* (Hall)**

(Pl. 13, figs. 10, 11)

1865 *Graptolithus quadrimucronatus* Hall: 144, pl. 13, figs. 1-10.

1907 *Diplograptus* [*Orthograptus*] *quadrimucronatus* (Hall); Elles & Wood 223-224, pl. 28, figs. 1a-d.

DISCUSSION. This species occurs in the *linearis* Zone at Dobb's Linn, and although it does not range higher, I have not examined any lower horizons in detail. It is associated with *Orthograptus truncatus* s.l. (Lapworth).

***Orthograptus truncatus truncatus* (Lapworth)**

(Pl. 16, figs. 3, 6)

1877 *Diplograptus truncatus* Lapworth: 133, pl. 6, figs. 1-7.

1907 *Diplograptus* [*Orthograptus*] *truncatus* Lapworth; Elles & Wood: 233-235, pl. 29, figs. 3a-e.

DISCUSSION. This species is more characteristic of the *D. clingani* Zone, but Elles & Wood (1907 : 235) said it was also abundant in the *linearis* Zone. I have only found a few specimens in this zone, together with one wide (4.2 mm.) fragment from the *anceps* Zone (Pl. 16, fig. 6).

Orthograptus truncatus abbreviatus Elles & Wood

(Pl. 15, figs. 4-6, Pl. 16, figs. 4, 5)

1907 *Diplograptus* [*Orthograptus*] *truncatus* var. *abbreviatus* Elles & Wood: 235-236, pl. 29, figs. 6a-c.

DISCUSSION. This subspecies is abundant in, but restricted to, the *anceps* Zone where it swarms on some bedding planes. The sub-fusiform appearance (Pl. 16, fig. 4) is very characteristic. It occurs with all the fauna of the *anceps* Zone but particularly with *Diplograptus fastigatus* (Davies), which species it originally included.

Orthograptus truncatus pauperatus Elles & Wood

(Pl. 16, figs. 1, 2)

1907 *Diplograptus* [*Orthograptus*] *truncatus* var. *pauperatus* Elles & Wood: 237, pl. 29, figs. 5a-d.

DISCUSSION. This subspecies occurs in crowds on bedding planes in the *linearis* Zone, often to the exclusion of other forms (Pl. 16, fig. 1). It does not range higher.

Orthograptus truncatus socialis (Lapworth)

(Pl. 13, figs. 7-9, Pl. 16, fig. 7)

1880 *Diplograptus socialis* Lapworth: 166, pl. 4, figs. 13a-e.1907 *Diplograptus* [*Orthograptus*] *truncatus* var. *socialis*: figs. 7a-e. Lapworth; Elles & Wood: 237-238, pl. 29, figs. 7a-e.

DISCUSSION. This subspecies occurs in crowds in the *complanatus* Band at Dobb's Linn, and many of the specimens show good growth line structures. It occurs rarely in the *D. anceps* Zone.

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PETER TOGHILL, B.Sc., Ph.D., F.G.S.,
Department of Palaeontology,
 BRITISH MUSEUM (NATURAL HISTORY),
 LONDON, S.W.7.